PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference TS 6457 PCT	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/052652	International filing date *(day/month/year)* 25.10.2004	Priority date *(day/month/year)* 24.10.2003
International Patent Classification (IPC) or national classification and IPC G01V1/50		
Applicant SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 8 sheets, as follows:
      ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19.08.2005	27.01.2006
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Lorne, B Telephone No. +31 70 340-1002

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/052652

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1, 4, 5, 7-13	as originally filed
2, 3, 3a, 6, 6a	filed with telefax on 23.08.2005

Claims, Numbers

1-15	filed with telefax on 23.08.2005

Drawings, Sheets

1/4-4/4	as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3,6,8,11,12,13,15
	No:	Claims	1,2,4,5,7,9,10,14
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-15
Industrial applicability (IA)	Yes:	Claims	
	No:	Claims	1-15

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following document:
D1: US-A-5 615 115 (SHILLING ROY B) 25 March 1997 (1997-03-25)

The invention relates to a method of assessing pore fluid pressure behaviour in a region of interest. According to the embodiments of the description, the presence of non-hydrostatic pore fluid pressure can be detected in a region of interest, which is located ahead of the drill bit device, with the measurement of formation stress whiledrilling above the region of interest. An abnormality in the pore fluid pressure in the region of interest can be detected since it affects stress in a formation above the said region of interest. Such a method is not disclosed in document D1.

However, the scope of the subject-matter of claim 1 is much broader.
The wording "the measurement region being located displaced from the region of interest" used in claim 1 is very general and leaves the reader in doubt as to the meaning of the technical features to which it refers. Thus, in the light of document D1, the location away from an offset well can be interpreted as being the region of interest that is displaced from the measurement region (the existing offset well).
Moreover there are no specific technical features indicating how the stress values are used to detect the presence of non-hydrostatic pore fluid in the region of interest.
In document D1, the stress values measured in the offset well are also used to detect the presence of non-hydrostatic pore fluid pressure in the region of interest.

Therefore, the present application still does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

Document D1, which is considered to represent the most relevant state of the art, discloses a method of determining a pore pressure in a region of interest in a subsurface formation below an earth surface (column 2, lines 57-60) comprising the following steps :
-two or more stress values representative of formation stress are determined in a measurement region of the subsurface formation located displaced from the region of

interest (column 6, lines 34-59 and fig.5);
-the stress values are used for determining the presence of non-hydrostatic pore fluid pressure in the region of interest (column 3, lines 20-29; column 4, lines 40-49).

The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent system claim 14, which therefore is also considered not new.

Dependent claims 2-13 and 15 do not appear to contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty or inventive step, see document D1 and the corresponding passages cited in the search report.

fluid in the bore hole, a so-called kick which can result in a blow-out.

Currently available pore fluid pressure prediction techniques in the art are normally based on determining a deviation in the porosity from a normal compaction trend of the formation, which determines the porosity. Such a technique is thus based on determining undercompaction and is referred to as an undercompaction technique. In such techniques it is generally assumed that over pressure is associated with abnormally high sediment porosity. However, over pressure does not always have a strong porosity-based signature, because over pressure can be caused by varying geological processes and are frequently related to complex geological structures, such as diapirs and overthrusts.

It is therefore an object of the invention to provide a more reliability added method for assessing fluid pressure behaviour in a region of interest.

In accordance with the invention, pore fluid pressure in a region of interest in a subsurface formation below the earth surface is assessed in a method wherein two or more stress values representative of formation stress are determined, each at a different depth in a measurement region of the subsurface formation being located displaced from the region of interest, and wherein the stress values are used for detecting presence of non-hydrostatic pore fluid pressure in the region of interest.

It has been found that the formation stress in a region displaced from the region of interest, is affected by the formation pore fluid pressure in the region of interest. The invention is thus based on the insight that observation of the formation stress in the

measurement region outside the region of interest provides information on the pore fluid pressure in the region of interest. For instance, pore fluid information can already be obtained with respect to a region that has not yet been reached in a drilling operation.

It is an advantage of the invention that results can for instance be used in deciding about which mud weight to employ and/or setting casing.

The method of the invention is stress-based rather than porosity-based, and therefore it is less dependent on porosity state of the formation than is the case in undercompaction techniques. Added reliability is gained compared to porosity-based methods, at least in that a high pore pressure is detectable in cases where high pore pressure is not accompanied by undercompaction.

The method of the invention can be utilized on its own merits, or as a complementary technique in combination with existing methods.

The region of interest may in some preferred cases be a subsurface hydrocarbon reservoir.

The invention is particularly advantageous in a case where the pore fluid pressure in the region of interest is an over pressure, being a pore fluid pressure that is higher than the purely hydrostatic pressure, because the stress in the region of measurement can then be used to predict the over pressure and thereby a kick during drilling can be avoided. If successfully applied prior to drilling, the method will assist in exploration of hydrocarbons in high pressure regions and in optimum well design.

In an embodiment of the invention, the use of the stress value for detecting non-hydrostatic pore fluid

pressure in the region of interest includes inferring an effective stress value representative of the difference

formation damage by intrusion of drilling fluid can be avoided in case that the abnormality is an under pressure.

The invention is also embodied in a system for assessing pore fluid pressure behaviour in a region of interest in a subsurface formation below an earth surface, the system comprising:

- a measurement arrangement capable of producing two or more signals each representing a stress value representative of the formation stress at a different depth in a measurement region of the subsurface formation; and
- a signal processing device arranged to receive the signal and utilize the signal to detect presence of non-hydrostatic pore fluid pressure in the region of interest, which region of interest is located displaced from the measurement region.

The measurement arrangement can, for instance, be a system suitable for remote geophysical detection techniques, such as a 3-D or 4-D (i.e. time-lapse) seismic technique.

In addition, the measurement system preferably includes at least a measurement-while-drilling device that is installable on a drill pipe for lowering into a bore hole such that the measurement while drilling device can reach the measurement region. For the purpose of this specification, a measurement-while-drilling device is to be construed to include a measurement-ahead-of-the-bit device, whereby the measurement region lies ahead of the measurement-ahead-of-the-bit device when seen in drilling direction.

These and other features and preferred features of the invention will be elucidated below by way of example and with reference to the accompanying drawing, wherein

13. The method of any one of the previous claims, wherein prior to assessing pore fluid pressure behaviour in the region of interest:

- a drill bit is provided on a lower end of a drill string; and
- the lower end of the drill string is lowered in a bore hole in the subsurface formation,

and wherein during assessing the pore fluid pressure behaviour in the region of interest:

- the drill bit is operated to deepen the hole.

14. System for assessing pore fluid pressure behaviour in a region of interest in a subsurface formation below an earth surface, the system comprising:

- a measurement arrangement for producing a two or more signals each representing a stress value representative of the formation stress at a different depth in a measurement region of the subsurface formation; and
- a signal processing device arranged to receive the signal and utilize the signal to detect presence of non-hydrostatic pore fluid pressure in the region of interest, which region of interest is located displaced from the measurement region.

15. The system of claim 14, wherein the measurement system includes at least a measurement-while-drilling device that is installable on a drill pipe for lowering into a bore hole such that the measurement-while-drilling device can reach or approach the measurement region.

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C L A I M S

1. Method of assessing pore fluid pressure behaviour in a region of interest in a subsurface formation below an earth surface, wherein two or more stress values representative of formation stress are determined, each at a different depth in a measurement region of the subsurface formation being located displaced from the region of interest, and wherein the stress values are used to detect presence of non-hydrostatic pore fluid pressure in the region of interest.

2. The method of claim 1, wherein detecting presence of non-hydrostatic fluid pressure comprises detecting a pressure boundary wherein the pore fluid pressure changes from hydrostatic to non-hydrostatic.

3. The method of claim 1 or 2, wherein detecting presence of non-hydrostatic fluid pressure comprises detecting a precursor zone wherein the pore fluid pressure is hydrostatically determined and a stress gradient increases.

4. The method of claim 1 or 2, whereby the fluid pressure in the measurement region is hydrostatic.

5. The method of any one of claims 1 to 4, wherein the measurement region of the subsurface formation is located less deep as seen from the earth surface than the region of interest.

6. The method of any one of claims 1 to 5, wherein using the stress value for detecting non-hydrostatic pore fluid pressure in the region of interest includes inferring an effective stress value representative of the difference between the formation stress in the measurement region

13. The method of any one of the previous claims, wherein prior to assessing pore fluid pressure behaviour in the region of interest:

- a drill bit is provided on a lower end of a drill string; and
- the lower end of the drill string is lowered in a bore hole in the subsurface formation,

and wherein during assessing the pore fluid pressure behaviour in the region of interest:

- the drill bit is operated to deepen the hole.

14. System for assessing pore fluid pressure behaviour in a region of interest in a subsurface formation below an earth surface, the system comprising:

- a measurement arrangement for producing a two or more signals each representing a stress value representative of the formation stress at a different depth in a measurement region of the subsurface formation; and
- a signal processing device arranged to receive the signal and utilize the signal to detect presence of non-hydrostatic pore fluid pressure in the region of interest, which region of interest is located displaced from the measurement region.

15. The system of claim 14, wherein the measurement system includes at least a measurement-while-drilling device that is installable on a drill pipe for lowering into a bore hole such that the measurement-while-drilling device can reach or approach the measurement region.